Mechanical Design Of Collins Amateur Equipment

by Fred Johnson
6202 Hilltop Trail
Sachse, TX 75048

Part 1

Previous articles in *ER* have described functional characteristics, design features, history, and development accounts of Collins amateur equipments. Ray Osterwald's, NØDMS, articles are a great contribution! My earlier article discussed Collins equipment reliability. There seems no end to what could be written.

Collins' influential role in amateur radio's history accounts for continuing interest in these subjects. Because authors of previous articles are mostly electrical engineers, it occurred to me that there is further information of possible interest. That is, the design of Collins equipment as seen from an involved Mechanical Engineer's point of view.

Bear in mind that some of the following recollections are about 40 years old. A little slack must be allowed for minor lapses in memory of details. And, of course, things always look better through hindsight. There will be some inevitable redundancy. I'll try to keep it to a minimum.

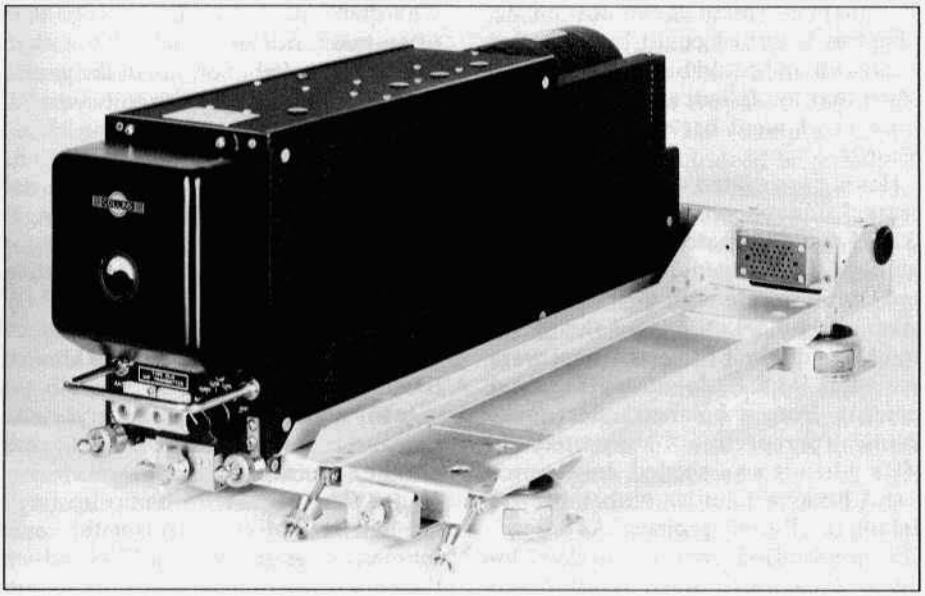
To understand the context of what follows, here is a view of situational details during a major era of Collins amateur equipment development. That is, the very late '40's to mid '60's.

During a substantial portion of the period I'll discuss, my boss was Ernie Pappenfus, K6EZ. Ernie was the E.E. department head for about half of Collins development programs under the chief engineer. Ernie had several E.E. groups. They included one responsible for amateur equipment. Ernie was a quick study. He was action oriented. I think it was Ernie whom I first heard say to a procrastinating engineer: "What are you going to know next week that makes it better to wait than to make the decision right now?". This has proven to be a timeless thought. A lot of Collins amateur equipment bears the imprint of Ernie's decisions.

Under Ernie, I headed a group of mechanical engineers. Engineers from my group were assigned to equipment development programs in the E.E. groups, the amateur line included. Usually, one M.E. was assigned per program. For his day-to-day instructions, an M.E. would report functionally to the equipment Project Engineer – who was almost always an E.E.. However, the M.E. reported organizationally to my mechanical engineering group for coordination and administrative purposes.

This matrix organizational scheme helped avoid the reinvention of wheels. It also provided technical backing to each engineer when tough problems came up. Much of the technology of then-concurrent avionics and military development programs was available to amateur equipment engineers via this method of organization. Collins had a powerhouse of available capability. This concept of organization is still being employed by progressive design organizations.

Virtually all E.E.'s working on amateur equipment developments at Collins Radio were hams. Most of the M.E.'s and I were not. However, I had electronics background from a lifelong interest in "Radio". I built receivers starting with UV-99's. Also, I had taught electronic and radio fundamentals in



17L-2 VHF airborne voice transmitter designed in 1948/'49. Art Wulfsberg, EE; Fred Johnson, ME.

the service. My heavy interest in high quality audio originated with the design and construction of pre-war amplifiers for sound reinforcement. Some were used for what would today be called "disco" applications. Later, I built post-war Williamsons, and Ultra-linears, as soon as they were known.

After the war, I was infected with an intense interest in design and construction of FM receivers, for their FI and noise-free promise. I liberated some acorn tubes when they were first available. They were "romantic". They worked well in the 50 MHz range. Remember, FM was still on the low band. That was before the shift to 88-108 MHz -- megacycles then!

This latter effort, into FM RF/IF/Limiter/Discriminator design and construction, continued at moderate level until about '60. It then became a full scale push. I had a serious case of the hots to receive "Good Music" station WFMT from Chicago. At Collins, I was of course in Cedar Rapids, Iowa, 200 miles distant. This quest lead to , in addition to the construction of an advanced receiver itself, the construction of a 72-ft. tilt-over tower, twin stacked 10-element center-band-tuned Yagis, specially constructed air-spaced 3/4" copper tube rigid 75-ohm coax down-lead, with stretched-to-diameter inner conductor, 300-ohm-to-75-ohm balun design (with E.E. help), and, purchasing a lot and building a house on the second-highest hill in town. The house location was arranged on the lot so the tower base was within a 12 foot flex coax run of the receiver input connector. Hams have no corner on fanaticism! I still have that receiver. I couldn't bear to discard it. But this is a continuing story.

The quest to receive WFMT was an illuminating lesson in real statistics! With this rig, my reception from Chicago was in the high 90% range. On that basis, the project could probably be judged a success. BUT, and this is a very big but, there is no innovative way in the world to inject a couple percent of fade noise, airplane flutter, or muting -- no matter how it is distributed -- and

continued next page

maintain enjoyment of classical music. I kept at it until I could buy a better receiver than I could build. Eventually, when that too failed, and the romance wore off, I went back to listening to records.

Having associated with EE's over the years, I understood what part of their skills I couldn't match. With a few exceptions, I could generally understand and communicate with them. So, I was often a technical arbiter for the M.E.'s and E.E.'s on their projects. There were many E.E./M.E. trade-offs that required steering from a balanced electromechanical perspective. I supported the ME's when it was needed. In the process I became familiar with technical details of all their projects. As a practice, we studied our own earlier designs. Also those of competitors, to guide our design decisions. The best that was possible was always the objective.

With that having been said, what follows is a few selected M.E.-oriented topics that come to mind. They are arranged in no particular order. Others are welcome to improve on the chronology before everyone has forgotten.

Arthur Collins, WØCXX, and his high-level engineering managers, were noted for pulling together "Tiger Teams", or task forces. Selected individuals would be picked to become a team to work with high intensity on very focussed subject areas. The entire SSB program is a good example. It has been cited before, and will be mentioned again. This kind of operation became legend. It was effective. In some quarters it was not liked. But, it prevailed.

In one such setting I heard Arthur Collins admonish an engineer with: "Look, we want to adapt and apply, not innovate or invent". It was a perfect choice of words for that one very specific circumstance. Arthur was really skilled at precision expression. But, like so many other times, this kind of quote was often repeated, and, unfortunately, often taken out of context. I saw that happen too often. For one of the greatest innovators of his time to have said it, it was an unlikely-sounding statement. Yet, to fully appreciate its wisdom, one must understand the background in which it was said. Some engineers picked up on these concepts readily. Others couldn't. They didn't stay on his programs long.

A beautiful example of Arthur's precision expression will be quoted later in this article.

In my view, Arthur Collins' style was the purest form of LEADERSHIP. He got the best from his engineers. He did it not by "managing", rather by leading! His intellectual curiosity set the tone for many an engineer to build a productive and rewarding career. This is part of a story that's too large for here. It comes through little by little in other articles on Collins equipment, and the man, wherever they appear.

Well, as it happened one time, two ham engineers under Ernie Pappenfus had come up with a clever RF linear amplifier concept. They had done it more of less on their own time -- in typical ham fashion. One of the pair was Gene Senti, WØROW. Gene is an E.E., and has contributed to earlier articles in *ER* relating to Amateur products for which he was responsible. The other engineer was Arlo Meyer, WØLBK. Arlo is that rare ham who is an M.E. Although Arlo wasn't directly responsible for amateur equipment design at that time, he was always watching over the shoulders of those who were. Being the quick study, Ernie learned of this linear amplifier that was gestating in the basements of his employees. The whole concept was slick. Ernie grasped its potential and wanted to add the amplifier to the S-Line as a fully developed Collins product.

What Ernie saw had come about something like this. Arlo helpfully re-

freshed me on these details. Gene had mounted the four 811A's with their output network on a nondescript chassis. When Arlo saw it, he thought, "Holy Cow, I could put that in an S-Line case and have an amplifier that I really want". He got together with Gene. The two of them worked out a general layout, tubeless power supply, etc. They bought the power transformers, tubes, SCR's and got two cases from the Collins salvage store. Arlo made sketches of necessary chassis and mechanical parts and personally punched and formed two sets of metal parts in the lab shops. He got the metal parts finished in production, with the help of manufacturing contacts with whom he worked day-to-day. He and Gene then assembled and wired the units. Gene's unit was apparently the first one that caught Ernie's attention. Arlo had no idea that this would be considered for production, since he knew the construction standards that would apply.

My recollection is that at the start of the 30-L development, from these humble beginnings, Bob Cox, Collins Chief Engineer, and Ernie's boss, had no funding for such a program. Not to be deterred, Ernie called together a half dozen engineers and literally locked the group in a vacant room previously used for a classified project. Ernie had food brought in for lunch and dinner every day. The goal was to do nothing but to make Gene's and Arlo's linear amplifier into a full-blown Collins "product" ASAP.

The kick-off for this exercise was a Wednesday (Tues.?) morning at about 9 AM. Ignoring for a moment the frantic efforts meanwhile, the first operational 30L-1 was functional and being tested at 6:00 PM on the following Saturday. Back then, we didn't count days very much. Arlo reminds me, nights either!! When completed, that first operational model had been built completely from a mechanical design layout, and its subsequent detail manufacturing drawings. Gene and Arlo had already made many design decisions. They had the operational proofs that are part of any product development. For example, that the four 811A's could indeed be packaged this way and work. That design effort didn't have to be redone. What remained to be done in the "lockup", and on a compressed schedule, was largely the design "packaging" and proof of performance testing. A few special components had to be found. New specifications for them were prepared. Suffice it to say, it was a very busy few days. With little additional design touchup the design was released for production in what amounted to a KWM-2 case.

Because it took just a few days, development cost for the 30L-1 was small. I've never been privy to any information indicating this smuggled project caused anyone gas pains. It was an example of what competent people can do when the objective is clear, and the boss is looking over your shoulder -- and carrying in food.

During those frantic few days, when anyone asked what had happened to the "missing" engineers, the secretaries would respond: "They are in the green room". The walls of that particular room were indeed green. That color was notable because the entire remainder of the building was a more or less industrial drab color -- beige, maybe.

As the years have gone on, and there have been other panic jobs, many have adopted the name "Green Room". The name stuck throughout the company. It is still used today to describe heroic efforts. A few of us remember the origin. **ER**

Part two next month.

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by Fred Johnson
6202 Hilltop Trail
Sachse, TX 75048
Part 2

After the rush was over, both Gene and Arlo sold their home constructed "30-L's" to outside hams. They replaced them with CRG units. "CRG's" are units returned from customers and refurbished by the factory to original performance specs.

Arthur Collins had previously organized a similar but larger task team to "practicalize" SSB. One of my M.E.'s was on that team also. That group was housed in Butler buildings behind the main plant. That was late 40's, very early 50's. The SSB program was a classic application of "adapt and apply" vs. invention or innovation. Much of what was done in the Butler building project was applying and refining known principles. At that time we had new steep-slope mechanical filters, very stable oscillators, and most of the "tools". Linear amplifiers still needed improvement, and the measurement equipment to do that had to be created. In order to get RF spectral purity one needed a way to look at the spectrum. A real-time video graphic spectrum analyzer to do that was developed in the department. Numerous copies of the analyzer were put into broad usage. Nowadays one would go to HP and choose among models. At that time there was no alternative but to build the essential test equipment in-house.

The SSB group that worked in the Butler building also got to be known as a "Butler Building" project. But the Butler name didn't stick over the ensuing years nearly as firmly as the Green Room name did. The term Green Room had been in earlier use to describe waiting rooms for artistic performers before they take the stage. However, I don't recall any earlier use of the name Green Room to describe a sweat shop as it came to be known at Collins.

My comments here apply mostly to the portion of Collins engineering that reported to Ernie Pappenfus. The other major engineering department, not under Ernie, handled avionics, aircraft instruments, space equipment, and some government programs. Suffice it to say that they also had a mechanical engineering group. It was an organization conceptually similar to Ernie's. The other mechanical engineers, and we in our group, coordinated on many technical matters. Their technical resources were available to us working on Amateur equipment. Special instrument-grade gear design is a good example. They also did a lot in the thermal evaluation area which we picked up on. That was especially valuable as we designed forced airflow cooling of external anode tubes. But, more on that presently.

Mechanical engineers working on other projects in our group were also a source of help on amateur equipment design. We were seldom unable to find a competent source of good advice or help within an hour or two. The net result is the quality of designs that are now out there to be seen.

It's interesting to think what would have been possible if we had had today's computer-aided design tools, programmable test equipment, today's measurement capabilities, circuit simulation, etc. I recall co-workers stretching out long fan-fold sheets of graphical computer printouts from a mainframe chain printer. The mainframe had been pro-

The author receiving 30 year Collins service pin from Bob Mullaley in 1978, while VP of microwave engineering.

grammed for elemental RF filter design. What a comparison to what's routine today!

It's only fair to say here somewhere that more good mechanical engineering was done by E.E.'s at Collins, than was good electrical engineering done by M.E.'s. Many of those E.E.'s are still friends. They deserve recognition. Remember though, that when one goes to look at a potential purchase, what do you see? The mechanical things, not electrons.

Arthur Collins strongly encouraged the use of computers for design and simulation purposes. It became a major issue in his plans for the organization. As he foresaw the future of computers in design and manufacturing, he communicated his visions repeatedly, and in many forms. For some engineers and managers the message was understandable though very difficult to implement on Arthur's schedule and at that time. For others, the concepts were unfathomable. But, that's part of a much broader story. The earliest mechanical design use of the mainframe I recall was when we had the programmers prepare a table of squares of integers from 1 to 100,000. We had these tables printed and distributed. This was for use in precision gear center coordinate calculations. The slide rule fell far short of necessary precision. Pocket calculators were still far in the future. How crude that looks today. Yet, it made possible design of gear center location accuracies to 5 places in record short time.

Mechanical design of Collins tuning mechanisms almost always included analysis of the effects of differential thermal expansions. Material choices were made accordingly. How these affected tuning stability was the issue. There was also a conscious effort to calibrate dial markings so their readability agreed with actual accuracy of the controlled variable. This is something Arthur wanted us to be fastidious about. If you could read it to a kHz, then that's what it was -- and vice versa. We saw flagrant violations of this principle in some competitive equipments.

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Coming back to a specific ham equipment, the KWS-1 was engineered in 1953 when the "New Engineering" building #120 was first occupied. Company employment was about 5800. Arthur named the new sideband amplifier with KW for its power, and "S" for sideband.

I remember some mechanical/electrical design discussions regarding how the KWS-1 was to be configured. We had a strong M.E. assigned. There was an even stronger E.E. project engineer! Parts layout for accessibility to manufacture the unit, and to maintain it, was a red hot topic amongst all of us. When the E.E. project engineer kept moving large power supply components around in the lower cabinet, for what he believed would be best accessibility, the frustrated M.E., who was facing a schedule for completion of fabrication drawings, said in exasperation: "Look, if you keep putting things up front, first thing you know something's in the back!".

In the KWS-1, we mechanically rotated (rocked) the body of the Permeability Tuned Master Oscillator for selection of upper or lower sideband. I believe it was called passband tuning. This was a mechanical way to get a desired frequency shift without affecting center frequency indication on the dial. It was a spring loaded low-friction speed reduction band drive. Other applications of this concept were in use elsewhere around the company.

The KWS-1 employed another spring-loaded band-drive to convert rotary knob inputs to linear movement on a rack of tuning slugs. The band-drive was again chosen for its freedom from backlash, for linearity, and for ease of tailoring to the travel requirement. That type of drive could be expected to last indefinitely without degradation in any of its functions. Life tests on similar designs had been run before, so the choice was obvious. Important, but not foremost, was the fact that the mechanical band-drive is also economical.

There had already been a long history of advanced mechanical design applied to tuning functions. The Collins Autotune, invented by Arthur Collins himself, and Autopositioner, invented by Horst Schweigholer, and their derivatives, were examples. They were mechanically programmable rotary position memories. Today, that function would be executed electrically on a silicon chip – with immense capability to spare. But the application of mechanics for an electrical objective at this earlier stage of the game was virtually second nature to us. And, silicon for that job had yet to be invented.

An important mechanical characteristic of a mechanical tuning knob drive is its "feel" to the user. Our M.E.'s were alert to this important attribute. If it didn't feel good, it wasn't acceptable. About that time we marveled at the really fundamental work done by IBM on the tactile feel of their Selectric typewriter. If one canvasses users even today, the feel of the old IBM Selectric is still the standard by which every other keyboard is evaluated for "feel". IBM designed the instant of electric contact to be coordinated with the arrival of the keyclick in the users ear, coupled with his or her feel of the slight over-center action. These are what gave the Selectric user a tactile confirmation that the key made contact. The whole thing was a marvel. Plus, it was hard to cause a jam! Compare that to your PC.! These great features of the Selectric were later written up in an article in Scientific American. Although Collins M.E.'s couldn't spend the man-years IBM put into their keyboard, we tried to emulate these principles in the manual controls of our products.

In my travels over intervening years, I have been surprised and pleased to have chance encounters with a few absolute strangers who own Collins gear, and who voluntarily made unsolicited favorable comments about dial feel as a factor in their enjoyment of owning Collins gear.

During this period we also learned some mechanical things to avoid. You won't find these in Collins gear of that period. For example, a free machining grade 303 stainless steel shaft must never be run in a free machining brass bushing. For example, a tuning shaft in a panel bushing. That combination is bad no matter what lubrication, surface finish or other variables. Agree -- it looks fine! BUT, it is bad news! You can bet that a small percentage of designs using this combination will eventually gall and seize. Not enough to be a big number, or to be readily found by ordinary tests. Just enough to kill a design engineer's valuable reputation.

Another bad combination is a free machining stainless steel shaft run in Oilite bearings. Here a manual drive will be OK, but a faster rotating motor-driven shaft can be sawed in half by the Oilite.

Yet another finding was that a heat treatment normally used to develop highest tensile properties in beryllium copper is accompanied by an unpublished change in bulk size. Not much, just enough to require compensation for precision drives. Now, back to specifics.

The upper cabinet of the KSW-1 housed the PA. The final amplifier tubes were 4CX-250's. Forced air was required for the fins of the external anodes. Everyone involved knew forced air is fine for reliability. However, forced air makes noise, and the typical ham shack is quiet. So, a blower was an unwelcome requirement -- especially in the eyes of an E.E. on whose turf the blower is a foreign object. In this case, the project E.E. believed the required blower should be located on the base of the bottom cabinet. A hose would be used to duct air from the blower up to the PA tubes. That configuration prevailed in all production.

Meanwhile, the M.E.'s were accumulating data on a better way. The world wasn't ready for that better way at the time. We were concerned because the hose and ducting hardware created such an additional pressure requirement that the blower had to be larger than it would have to be if the blower could be connected directly to the tube. Since that didn't seem practical at the time, we went ahead with the larger blower and hose.

A problem M.E.'s had to solve at that time was the ability to measure airflows and temperatures in the presence of high voltages and RF. Those skills were still embryonic. Thus the arguments to do the job right -- without a hose -- didn't prevail. By the time a later unit, the 30S-1, came along, the cooling job was done with a small, but adequate, blower right under the final tube socket. By then we had indisputably measured air flows and anode temperatures to show what the cooling system was doing. It was a good feeling to know the measured truth. It confirmed that desired margins actually existed. The hose was eliminated and the smaller blower was reasonably quiet. My earlier article touches on measuring temperatures and airflows.

The rest of the KWS-1 mechanical design was relatively routine for the day. The black crackle finish matched other products, and the dial escutcheon carried on the corporate image.

The 75A-4 was the SSB receiver companion to the KWS-1. We lavished on it the same design margins that were normal for the day. It is my understanding that present-day solid-state receivers still have trouble equalling or bettering its performance. Its appearance melded with the KWS-1 very well by design. The customer community knew its performance would be state of art. **ER**

Part 3 next month.

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by Fred Johnson
6202 Hilltop Trail
Sachse, TX 75048
Part 3

Concurrent with amateur equipment development, others in our group were working on new broadcast transmitters, consoles, etc. I found amusing the generally accepted belief that the new broadcast transmitters had to be physically large, even though technology allowed them to shrink to the size of a file drawer. Conventional logic seemed to be that. . ."What broadcast engineer would like to bring in a wife or friends and show them what he was the engineer of -- if it was a breadbox!". I guess it makes marketing sense if not engineering sense. In any event we made some broadcast equipment larger than necessary. Some "refrigerators" could have been the size of amateur units.

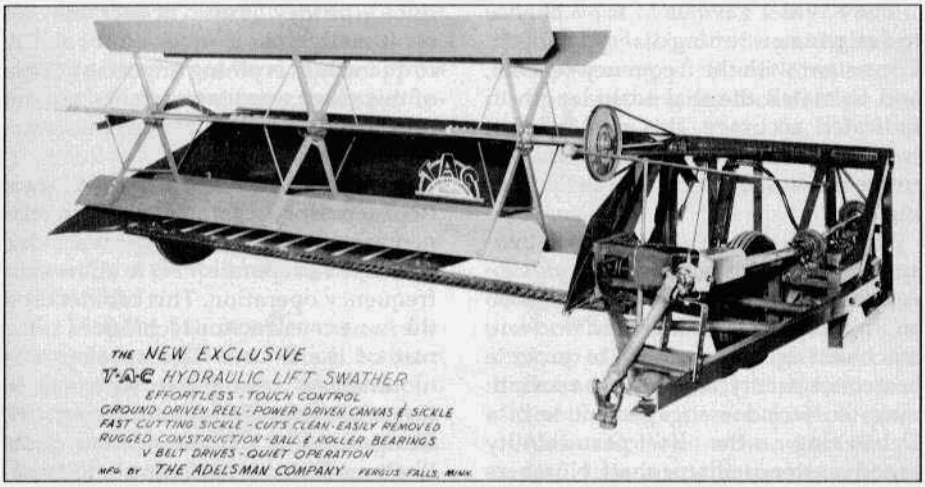
In 1956 SSB technology had progressed to the point that a portable transceiver could be built in a relatively small box. Gene Senti originated the concept and first demonstrated its possibility, if I recall correctly. Often it's hard to precisely pinpoint the origination of new concepts when like-minded people are all working together on the same set of opportunities. The type number assigned to this first transceiver of its kind was the KWM-1 (M for mobile). The KW identification was used to capitalize on the success of the KWS-1, though the new "M" was not a KW in either input or output. A salient feature: it was "small". We designed it in a gray-painted monochrome aluminum case with very slightly rounded corners, and few styling features.

The KWM-1, being small and "mobile", made it possible to design a mount that would accept the unit as a plug-in on the transmission hump of an automobile. It's interesting to recall that our M.E. group was short handed at that time. As a result, Ernie Pappenfus requested Arlo Meyer to survey all the new cars at local dealerships on his own time. Purpose was to define the dimensions of the radio's mount on the transmission hump. Arlo was working other assignments outside the ham group at the time. Because Arlo was a ham, and an M.E., he took the challenge for some side "consideration" that a ham would surely appreciate!

It's interesting to see today that valuable auto radio components are treated similarly. They, too, unplug for removal of a unit from the car. There's a size difference, but our principle was the same as you see used today.

For convenience in changing frequency, the KWM-1 had a specially designed plug-in crystal/turret switch assembly on the front panel. It allowed multiple crystals to be inserted as a gang for pre-set frequency selection. Considering today's synthesizers, I guess this looks pretty crude. But, it served well.

I also remember the design of spring loaded gears in this unit. They were used to forestall backlash in the tuning mechanisms. However, it became a never ending source of annoyance to me that the unit went to production with a dial that contra-rotated with its knob. Even though it met the other criteria for dials -- such as accuracy and fidelity to resolution -- this backwards rotation was a problem we couldn't solve within the constraints we had. I vowed not to do that again.


THE NEW EXCLUSIVE
V-A-C HYDRAULIC LIFT SWATHER
EFFORTLESS-TOUCH CONTROL
GROUND DRIVEN REEL-POWER DRIVEN CANVAS & SICKLE
FAST CUTTING SICKLE-CUTS CLEAN-EASILY REMOVED
RUGGED CONSTRUCTION-BALL & ROLLER BEARINGS
V BELT DRIVES-QUIET OPERATION
MFG. BY THE ADELSMAN COMPANY FERGUS FALLS, MINN.

Mechanical Engineers at Collins sometimes had strange beginnings. This swather was designed in 1947 by Bob Griswold (who later designed the R-390) and the author.

The KWM-1 apparently stimulated Arthur Collins' recognition that the old black wrinkle and plain gray boxes weren't going to cut it stylewise into the future. He made it known that something more modern or professional was needed. We had an internal Industrial Designer whom we taxed with coming up with something better. The KWM-2 was an initial trial. The perforated case, extruded aluminum front rim, and two-tone gray paint job were the starting point.

The KWM-2 was introduced in 1959, on the downhill side of amateur equipment development at Collins. Its development carried forward many proven features. It introduced a few that were evolutionary, if not revolutionary. Maybe the first to be noticed was the front styling rim on a perforated case for ventilation and thermal control. Of special note is the surface "texture" of the front panel.

As time had gone along, Arthur Collins made it known that, in his opinion, the front panels of this new style needed a surface texture of some kind. After we had experimented unsuccessfully with several processes that we had the capability to do, Arthur brought in his Hasselblad camera and said that something like the nubby leather grain it had would be nice. I can't tell you how many trials were made to duplicate that effect. But, the final solution was an actual photograph of the camera surface with negatives spliced and retouched to make a composite the size of the panel. It was used to expose phototresist on the aluminum panels which were then chemically etched. When painted, the surface was a reasonable duplicate of the camera. This panel finish was used throughout the S-Line.

Another sidelight is that the formed trim ring around the panel was designed to be an aluminum die casting. But, because extrusion dies are relatively cheap, early production used extruded and formed rings. Piecewise this was more expensive. Over the life of the S-Line equipments however, thousands more formed rings were used than were needed to justify the cost of casting dies. But, production releases were never for an individual run of sufficient size to justify die tooling. Marketing timidity, I guess!

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The KWM-2 gave us M.E.'s a chance to design a new tuning dial mechanism. Consistent with the frequency scheme, and to match the dial scale length to indicated accuracy, this demanded a two revolution dial. We made this one rotate in the same direction as the tuning knob!

The final design employed a low-spring-rate set of tempered beryllium-copper friction discs riveted to the knob shaft. After solid staking, the discs were machined as an assembly to provide best concentricity, and to make a smooth ramp surface for engagement with a Delrin ring on the offset permeability tuned master oscillator shaft. Numbers up to two hundred were silk-screened on a single backlit translucent dial. A tooth-shaped white masking pattern was silk screened over every other numeral on a transparent overlay dial. The two dials had different numbers of external gear teeth on the same pitch radius engaging a common idler gear. Thus, they rotated at slightly different rates. The net result is that the proper number is presented on each of the two rotations of a common scale. This is harder to describe than it is to recognize when you see it. I like to think of it as an example of deliberate mechanical slow motion aliasing.

This dial was as close as possible to backlashless. It felt good. Its costs were reasonable and its accuracy matched performance.

Another tuning mechanism designed into the KWM-2 was a 2:1 ball-planetary reduction slug rack drive. It made the knob easier to turn, and was a nearly effortless, toothless positioner. A band drive was combined with the planetary to eliminate backlash and to ensure linearity. To measure minute motions in cases like this, we glued tiny mirrors on the shaft or device being driven. Then an intense light reflected on the wall, or on a sheet of cardboard a suitable distance away, indicated the actual motions -- be they desired or backlash. We continually tried to improve our ability to quantify everything important. Some of this effort went into detents, but not much of that found its way into amateur equipment.

Along with the KWM-2 there were two accessory cabinets for miscellaneous items and a loudspeaker. One contained a separate VFO to allow split frequency operation. This cabinet used the same construction techniques as the rest of the S-Line. The speaker was mounted on a panel part way back in the cabinet to allow controls in front. Designing this cabinet led to a quote I've mentioned before, and will probably never forget.

Due to my interest in quality audio, I was concerned about having a speaker in a metal box. I expected it to sound "tinny". Being always interested in quantitative data, I took sample speakers outside into the back lot, faced them up in a free field, and placed a flat response microphone above them about three feet. I made several frequency response plots for variations in distance of the speaker's recess in the cabinet, and for different speakers, some with, some without fiberglass damping. Anyone who has ever done this kind of measurement knows that the method has some inherent, unavoidable flaws. It can also flood you with data that isn't easily interpreted. It's like a foreign language. Until you spend a lot time with it, you can't be fluent in it.

Anyhow, as usual, I had documented the experiment in my Engineering Notebook. I had response graph sheets on my desk when the chief engineer came into my office. He put one foot up on my desk, looked at the charts and data upside down for less than a minute. He said: "I don't think your data is worth a damn!". Knowing well that this kind of measurement isn't like checking the voltage of a dry cell, I decided not to argue. I let discretion be the better part

of valor. Today, one could apply a unit pulse to the speaker, do a time to frequency domain conversion, then plot a "waterfall" chart exposing the entire frequency vs. amplitude signature for a time following the pulse. This technology has advanced to the point it has credentials. It would have been nice to have had it then. When your boss' boss gives you a compliment like I got, it's memorable!

In 1960 the 51S receiver carried forward many of the mechanical features of its predecessors. The addition of a "speedometer-type" digital frequency dial was a precursor of yet to come additional digitalization of tuning. Spinner knob developments are too long a story to tell completely. That whole scenario is reminiscent of the analogous situation where a famous quote originated, that is: "Everyone with an ass is a seating expert". The knob shape, radius of indent, overall diameter etc., etc. were endless sources of opinions. What went to market was determined as much by a schedule deadline as it was due to unanimity of opinion.

Emphasis on amateur equipment design diminished in the '60's as Arthur Collins focussed on computer developments. In the mid '60's the 651S was developed. The 651S employed mechanical styling that had been brought into the company for new computer products. Ultimately, all Collins products adapted this new "look". One distinguishing feature of the look is a terra cotta color stripe across the top front of each unit. Outside consultants were the source of this new style. They also brought us a new corporate logo which lovingly became known as the "meatball". Some thought it appropriate for Hotpoint stoves. The M.E.'s worked with the consultants over a period of years as they gave us what has turned out to be a relatively timeless style for all products. They taught us to think about such things as how something would look when it's dirty. We mechanical types had to learn that screw heads were ugly! ! Sometimes, one has to do something for looks rather than just function.

The KWM-380 was the last real amateur product. It employed frequency synthesis for 10 Hz step tuning, plus other features which diminish the mechanical engineer's inputs to a design. Its large "motherboard" backplane made it a bear to test with techniques in general use at the time. Though it had continuous coverage, and many features, it did not have the personal involvement of Arthur Collins. Arthur was fully occupied with introduction of computer technology to communications. Arlo Meyer was involved with this last program of its type, and worked to get the KWM-380 into production in the Collins El Paso plant.

As time goes on, most of the need for mechanical engineering in electronics converges on thermal matters, board layout and design, and a few structural and vibration concerns. The days of complex mechanisms are over. Probably the epitome of mechanical tuning ingenuity and complexity was the R-390, designed for the Signal corps. My lifelong associate, Bob Griswold was the M.E. on that design. ER

Part 4 next month.

Mechanical Design of Collins Amateur Equipment

by Fred Johnson
6202 Hilltop Trail
Sachse, TX 75048
Part 4

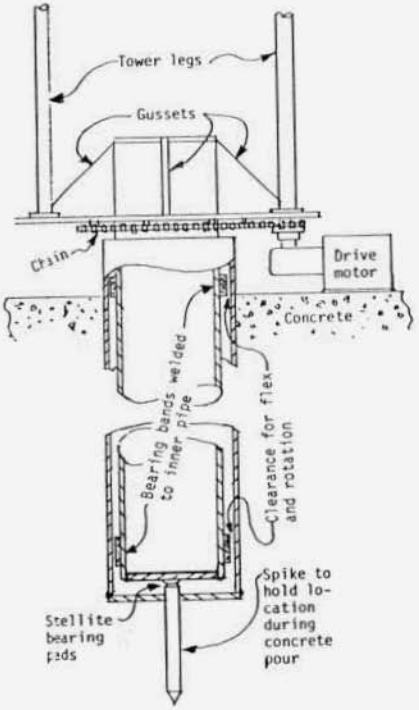
Amateurs who have rotators at the top of antenna towers will appreciate Arthur Collins' answer to rotator reliability problems. One day in the midst of other activities, Arthur stopped by to discuss the possibility of rotating the entirety of an 80 foot tower -- with antennas solidly attached at the top. I admit to a somewhat less than enthusiastic initial response. But, further thought showed it wouldn't be a tough job -- just unconventional. I had to get convinced that the tower could withstand the torque of available simple driving mechanisms. The start and stop jerks would have to now include the inertia of the tower in addition to the antennas. That turned out to be OK. The decision to go was made.

I calculated stresses and found 8 ft lengths of two appropriate sizes of large pipe. They were about 10 to 12 inches diameter. One nested within the other with about an inch clearance. I welded a half-inch thick, 3 inch wide band around the top and bottom of the inner pipe. The outside diameter of the selected band thickness produced a desired free fit to the inside diameter of the outer tube. Thus the inner pipe rotated freely in the inner diameter of the larger pipe. The inner pipe could bend slightly under load without binding. I welded Stellite pads in the center on the bottom of the inner pipe plug where it contacted the bottom plate welded in the bottom of the outer tube. This was an anti-friction non-galling rotary bearing for all the weight.

Trying to describe all this here convinced me a sketch could be more helpful than additional words. So, I'm including one. We keep being reminded that graphics is a potent method for communications among humans. Quite possibly the form of communication having broadest bandwidth, least distortion, greatest S/N, spread spectrum possibilities, and on and on. Still, we keep on with words, words, words. . .

The sketch shows a cross section of my design for the rotating tower support. On the inner pipe I welded a round platform that was gusseted to the top of the inner pipe. This inner rotating member comprised what I called a large lazy susan for the antenna tower. The outer pipe was buried in concrete in Arthur Collins back yard. The inner pipe was dropped in place and the space between it and the outer pipe was filled with diesel fuel. The tower was erected on the lazy susan. Antennas were mounted at the top. I had selected a large gear reduction motor which drove a large chain sprocket under the lazy susan plate. The antenna coaxes had slack loops at the bottom to allow somewhat more than a single revolution. Electrical stops determined the exact amount of rotary overlap. The scheme worked. Over time, a few more rotary towers were built and installed for high-level Collins engineering and marketing folks. I suspect some of them thought of that as a status symbol.

While the lazy susan was being readied for mounting, I applied bonded resistance strain gauges in selected high stress locations on the structure. When the tower was up, I climbed to the 40-ft level and attached a rope. An interested E.E. came with me and pulled on the rope with a calibrated fish scale at a



predetermined angle. I read the strains at highest stress locations at the base, converted to stress, and decided on additional gussets so the tower would handle anything short of a tornado. There was one unfortunate incident in this exercise. A construction truck backed into soft sod on Arthur Collins' next door neighbor's back yard. You can't imagine how fast that got fixed!

As amateur equipment development programs were fading, I was called to an in-progress meeting one Saturday morning as I came in to my office. I had come in to catch up on other things. Arthur Collins had collared perhaps a dozen or slightly more embryonic computer engineers. They were seated around a long table in a conference room. I took a seat in the on-going meeting. It took no time at all to see that things were not going well. Having missed the earlier part of the meeting, I didn't understand what the basic issues were -- and said so. Immediately! Arthur Collins stood up at the blackboard and gave me a 15-20 minute tutorial on how transmission lines work. It included impedance vs. geometry, terminations, reflections, and how they relate to applications in multilayer backplanes. Think back! The word backplane had hardly entered the language at that time. It was a very intense learning experience!!

Upon conclusion of that tutorial, the meeting broke up. I returned to my office to do what I had come in to do in the morning. At about 2:30 that afternoon I looked up from my desk. Arthur Collins was leaning against one side of my office door frame. When he saw he had my attention, he said: "You see, Fred, it's all mechanical after all". Having said that, he left. He knew my background. He had tailored the transmission line subject to my capability. He used terms he knew I'd understand.

I've often thought of that example of person-to-person communication. My receiver was turned on. Its bandwidth was as wide as I had. The transmitter put out a signal consciously shaped to my receiver's response characteristics. The message got through. Call it deliberate spread spectrum if you will.

As I thought back, I believe I saw a twinkle in Arthur's eye. I believe he got some jollies from getting his message across. Collins computers were early in the application of multilayer backplanes using controlled impedance transmission lines. Arthur's foresight had steered that course. I just happened to be in that path of progress.

Those of us who knew Arthur Collins often commented on how far ahead of his time he was. Estimates of five to fifty years were common. I couldn't have stumbled onto a more timely and relevant example than in the Dec. '93 issue of *Surface Mount Technology*. The magazine came out as this is being written.

continued on page 33

An article titled: "Packaging To The Year 2000" contains this quote: "Signal integrity of most 50 MHz systems will be dominated by transmission line effects. If the designers are not aware of transmission line properties, there is a good chance that the board will not work".

That author's point is precisely the message I got in the semi-private tutorial from Arthur in the mid '60's. IC's were still very new. IBM's 360 computer had just a few gates on each of its Solid Logic Technology ceramic chips. Arthur understood where all this was going!! Controlled impedance transmission lines were seen as an important element of it, as history has now proven. This is but one of thousands of examples of his clear view of technology's future.

The privilege of working with Arthur Collins has a priceless value never to be forgotten. As many will attest, it wasn't always easy at the time. However, the standards of excellence one learned, plus the brilliant and fundamentally correct ways of approaching design, were an inspiration. Many agree that, all together, it was a culture. I certainly believe that. As one looks over the employee alumni association from Collins, it's hard to miss the point that it was a unique and valuable environment for learning and growth.

A really keen insight to the native genius of Arthur Collins is illustrated by the following quote from an article he wrote on request of the magazine *Radio Age*, May 26, 1926. Arthur was in high school at the time. He had been communicating with the MacMillen Arctic expedition via his own design radios, where the "professionals" had failed.

"The real thrill in Amateur work, comes not from talking to stations in distant lands, nor from receiving multitudes of "QSL" cards from all over the world - although these are things that stir the imagination - but comes from knowing that by careful and painstaking work and by diligent and systematic study, you have been able to accomplish some feat, or establish some fact that is a step toward more perfect communication".

I am indebted to Warren Bruene for reminding me of this most inspirational quotation from the youthful Arthur Collins.

As a post script, there are a couple of accounts which are really a part the overall picture, but which didn't fit in as part of the subjects covered above. Yet, they demand to be related. They both deal with the survival of S-Line equipment which fell and "hit the deck", so to speak. The first is a letter we got from a ham shortly after the S-Line was on the market. The owner wrote of his unit being blown out a second story window by a high pressure fire hose that was dowsing a fire in his upstairs ham shack. The unit landed between houses on a concrete drive. The owner said that replacing a tube or two restored it to operation. He was ecstatic!!

What brought that forgotten story to mind was a conversation I had with Arlo Meyer as I was writting this. He mentioned that he had recently dumped his 30-L from a desk to the concrete floor by accidentally pulling a wrong coax. It landed on the upper rear corner by the tube compartment. His first thought was that the 30-L was surely totalled. The cover and sheet metal were heavily damaged. But, after prying the chassis out, and straightening panels with a soft hammer, and a two by four, the tubes were still solidly in their sockets, and the unit is in use almost every day -- as we speak.

A few years ago I had a related experience with a then new (almost all plastic) FAX machine. It slid off the top of my four drawer file cabinet to the carpeted floor. It didn't end up as well as the S-Line equipments! **ER**